Case Report ■

Case Report: Activity Diagrams for Integrating Electronic Prescribing Tools into Clinical Workflow

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Abstract To facilitate the future implementation of an electronic prescribing system, this case study modeled prescription management processes in various primary care settings. The Vanderbilt e-prescribing design team conducted initial interviews with clinic managers, physicians and nurses, and then represented the sequences of steps carried out to complete prescriptions in activity diagrams. The diagrams covered outpatient prescribing for patients during a clinic visit and between clinic visits. Practice size, practice setting, and practice specialty type influenced the prescribing processes used. The model developed may be useful to others engaged in building or tailoring an e-prescribing system to meet the specific workflows of various clinic settings.

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Introduction

Electronic prescribing ("e-prescribing") is defined as the use of computers to enter, modify, review, issue and/or transmit medication prescriptions.[1] Pilot studies have demonstrated that e-prescribing can reduce medication costs,[2,3] decrease clinicians' and pharmacists' time spent in clarifying prescriptions,[4] and reduce medication errors,[4–6] including errors of omission.[7] Although such studies provide substantial impetus for the adoption of e-prescribing technology, other studies document that issues related to the disruption of clinicians' workflows represent a countermanding force when transforming health care practices.[8,9] In addition, reports[10,11] indicate that unintended consequences may follow introduction of technology not well-suited to a particular environment. Successful implementations of e-prescribing systems require a deep understanding of prescription-writing workflows[12–15] and of how system implementation can impact them.

Prescription writing occurs in a variety of contexts, with specific roles performed by multiple individuals, each with varying levels of training and competency. A useful process modeling technique for representing dynamic behavior of information flow involves activity diagrams.[16] Activity diagrams employ traditional flowcharting techniques to model workflows, information exchange, and business processes.[17,18] The authors constructed activity diagrams for outpatient prescribing in a variety of contexts, with the goal of understanding the parameters required to integrate outpatient medication ordering into an electronic medical record system.

Methods

The e-prescribing development team at Vanderbilt consists of nurses, physicians, informatics experts, and programmers. To initiate construction of activity diagrams for outpatient prescribing, as a prelude to implementing e-prescribing, one of the authors (FF) interviewed a convenience sample of nineteen providers (nurses and physicians) practicing internal medicine, pediatrics, family practice, emergency medicine, oncology, cardiology, general surgery and vascular surgery care at Vanderbilt University Medical Center, a large hospital-and-clinic-based faculty practice in Nashville, Tennessee. Questions focused on who performed what aspects of the prescribing process, how often, in what contexts, and in what order. Based on these interviews, the authors constructed draft diagrams of the prescription-writing process. These models evolved based on feedback from questionnaires sent to another convenience sample of 10 outpatient practices in the Nashville area.

Results

Two activity diagrams were developed. The first diagram modeled workflow patterns involved in prescription-writing between patient clinic visits. The second diagram involved prescription-writing while the patient was present in clinic for either a scheduled or unscheduled visit.

Prescription Writing Process between Clinic Visits

Figure 1 summarizes workflows for manual prescription writing when the patient is not physically present. In summary, patients call the clinic office to request the prescription, and typically speak with a clerk or a nurse. Alternatively, a pharmacist may call the clinic to request renewal of an expired prescription. Both large and small group practices stated that phone requests from pharmacists or patients are the most prevalent initiator for prescription generation overall. Emergency departments receive but typically do not honor requests for renewals or new prescriptions; patients are instructed to visit the emergency department for evaluation first.

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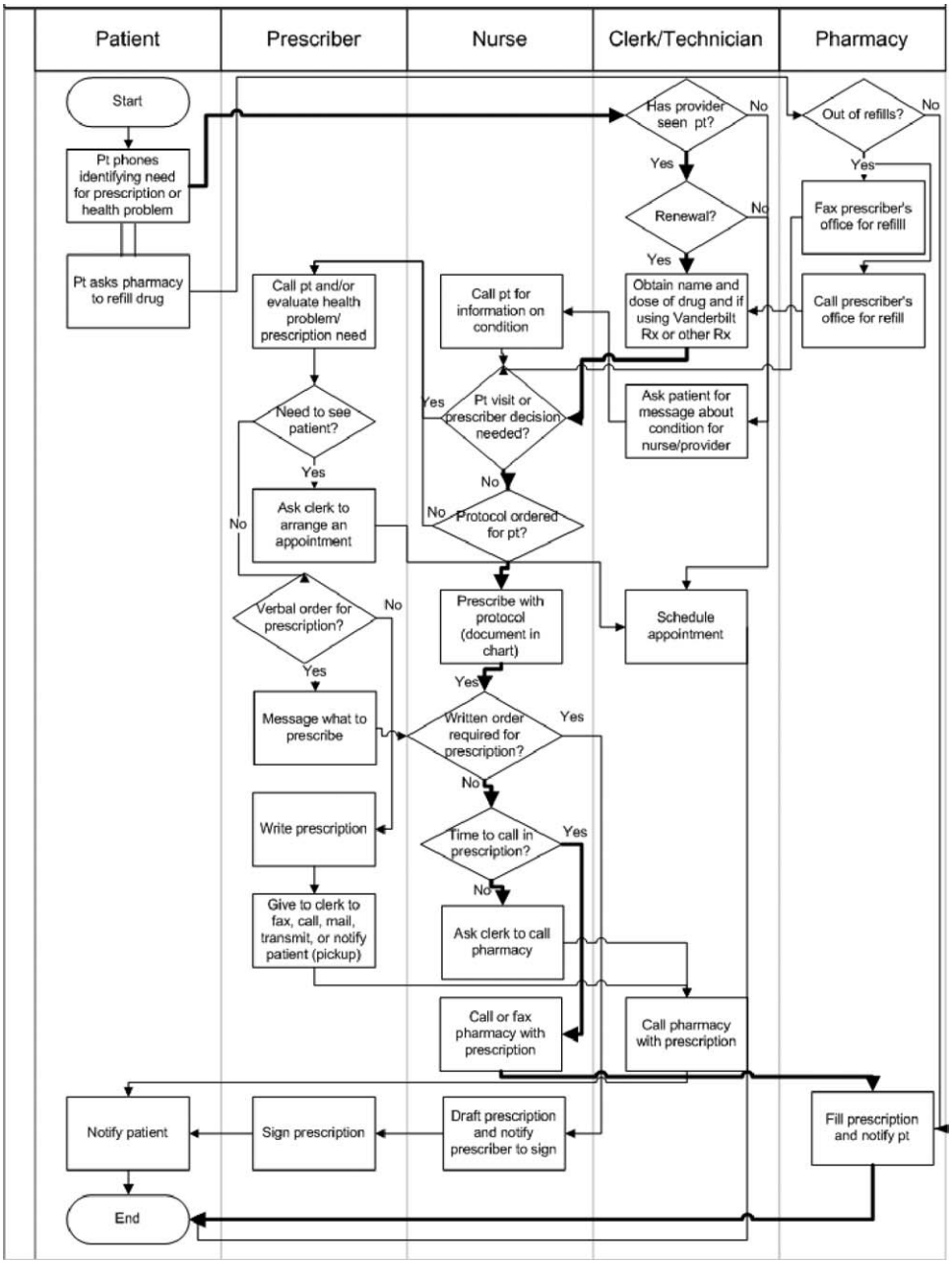

Figure 1. Activity diagram for prescribing before or after a clinic visit. Bold line represents most common pathway for prescribing.

Although prescribers may take sole responsibility for the prescribing process in some settings, in other settings, prescription generation occurs through collaborative processes, often involving support staff who draft and even phone in prescriptions ordered by authorized prescribers.

Prescriptions generated outside of a clinic visit are either faxed to the pharmacist, mailed to the patient (in the case of a chronic medication with an existing adequate supply), or physically handed to the patient or the patient's representative. Prescriptions for a Schedule II controlled (narcotic) medication require an original written prescription, so patient or family pickup is necessary.

Prescription Writing Process during Clinic Visits

Figure 2 outlines the general process for creating and transmitting a prescription during a clinic visit. To summarize, during clinic visits, three scenarios may trigger prescription generation:

- the patient arrives requesting a prescription for a previously prescribed medication, or for a new medication
- a care provider ascertains from the medical record that a prescription renewal is due (i.e., all refills on an existing prescription have been exhausted)
- a care provider decides to initiate a new prescription for a new medication, or for a previously prescribed but discontinued medication

During patient "check-in" for the clinic visit, nursing staff typically identify patients' prescription requests and identify medical-record-based renewal instances. The staff often draft such prescriptions and give them to the authorized

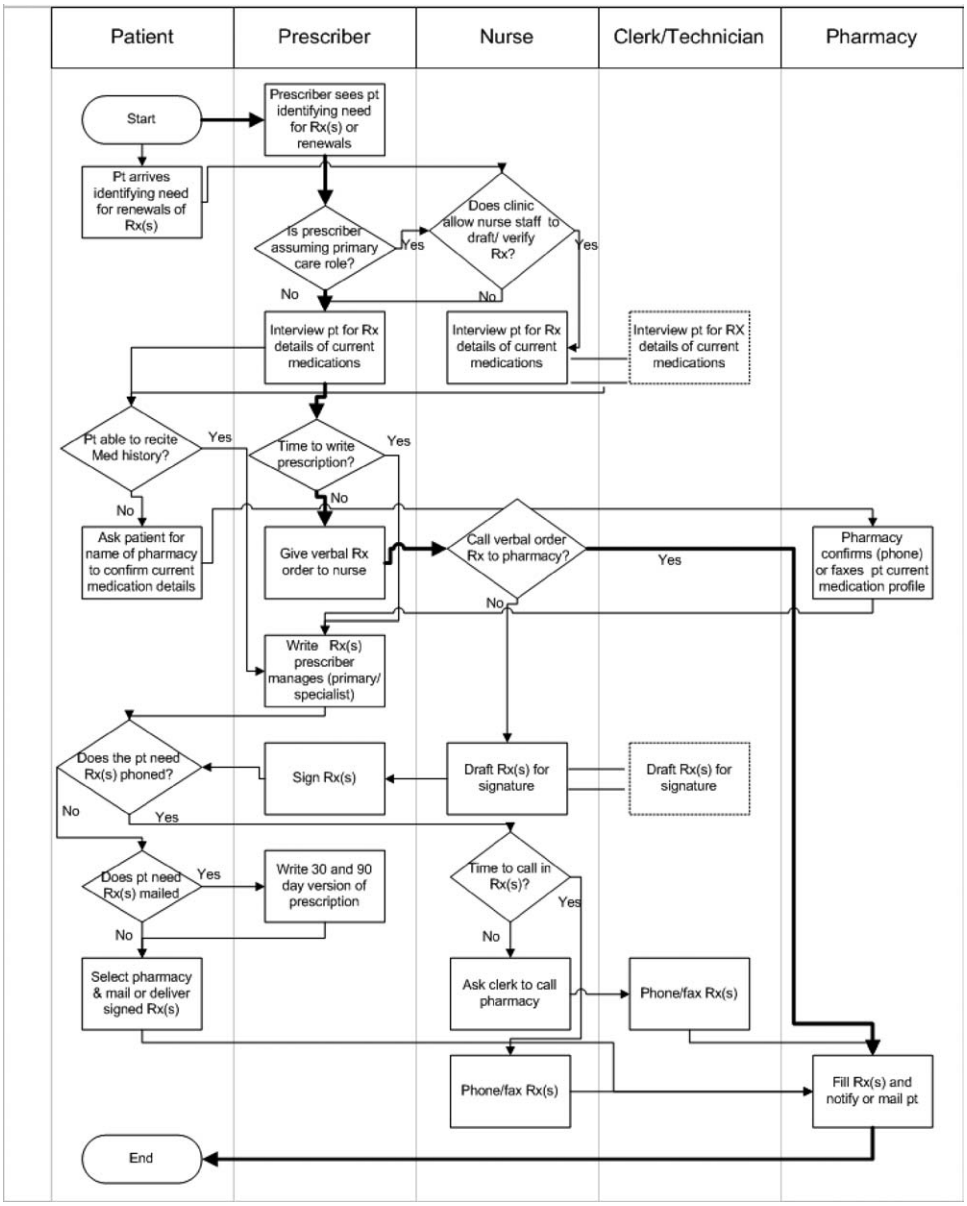

Figure 2. Activity diagram for prescribing during a clinic visit. Bold line represents most common pathway for prescribing.

prescriber for signature, or the provider may generate the prescription based on information furnished by the nursing staff.

Based on the patient's preference for prescriptions generated during a clinic visit, the prescriber's office phones the prescription in to the pharmacy, faxes it to the pharmacy, or hands it to the patient (or the patient's caregiver). How this happens is a function of who has drafted the prescription, since nursing staff are often allowed to fax or phone in prescriptions without significant supervision. If the pharmacy benefit manager provides 90-day supplies of drugs, specific forms may need to be completed and given to the patient, along with the printed version of the prescription, or faxed directly to the supplier. Patients typically are responsible for managing mail-order requests for drugs.

Discussion

Workflow analysis not surprisingly disclosed two scenarios that drive prescription writing: whether the prescription is requested during or between clinic visits. Analysis also identified two easily anticipated aspects of prescription-writing that affect workflow: whether the prescription is for a new or for an already prescribed medication.

By contrast, the range of tasks completed by non-authorized prescribers was surprising. Based on information garnered during this analysis, the e-prescribing development team at Vanderbilt fundamentally changed its prototypic e-prescribing application to better reflect (and support) workflows discovered for paper-based prescribing. For example, although it had been previously evident that secure messaging would constitute a useful method to notify a nurse that a prescription was awaiting printing, the new activity diagrams emphasized that a more common scenario would be the use of secure messaging to transmit a nurse- or clerk-initiated draft prescription that must be routed to a prescriber for verification and signature. The diagrams also altered the e-prescribing team's previous workflow designs for the medication refill process, because this activity was

often conducted with far less involvement by the authorized prescriber than previously envisioned.

Other observations that were not considered by the e-prescribing design team until after construction of the activity diagrams included the methodology for sending prescriptions to the pharmacy by facsimile. The team knew from the e-prescribing literature that ability to fax prescriptions was important, but the team had assumed that faxing would involve routing prescription orders to nursing staff. However, the survey results indicated that the nursing staff often did not receive the initial request for a prescription from the patient, so it became necessary for the team to implement a new method that allowed the person answering the phone (a clinical clerk in most cases) to select a the name of the patient's pharmacy from a "pick list" and then attach it to the prescription-request message. The team was unprepared to support this workflow prior to the surveys and resulting activity diagrams. The analysis also provided unexpected answers to some questions that had arisen early in e-prescribing development efforts:

- Whose electronic signature was most appropriate to place on the prescription if the nurse completes the prescription by protocol? *After discussions with stakeholders, the e-prescribing tool was configured to allow the nurse to sign the prescription with a comment ("for" and the provider name.) This signature is overridden if another authorized prescriber reviews the electronic prescription.*
- When should specific types of dose checking, allergy checking and other alerts occur? For example, should the person receiving the phone call have been able to see a dose-limit alert if this person was not in a position to complete a prescription? *Thus far, all staff see all alerts, although this question continues to be debated.*

A recent article by Bell and colleagues[19] proposed a set of functional capabilities of e-prescribing systems, as well as a process model to organize prescribing system evaluations. The activity diagrams in this manuscript complement the work by Bell, in that they present an expanded view of the prescribing workflow that may apply to various settings. Accommodating this workflow will be an essential component of e-prescribing adoption.[1]

The current preliminary study is limited in that it does not address several situations: prescribing medications that are dispensed locally; and, it ignores certain classes of medications, such as samples, alternative therapies, and dermatologic creams. The latter items may be prescribed either with more or less scrutiny, respectively, than other types of therapy. This level of scrutiny is likely to affect workflow; for example, a clinic might choose not to involve the clerk in any phase of the prescribing process for medications they will dispense during the visit. It is expected that workflows would be streamlined based on the risks associated with these medications.

As a prerequisite for successful e-prescribing system implementation, organizations contemplating electronic prescribing should analyze the prescription workflow patterns occurring under "baseline conditions" at their own institutions before purchasing and installing the system. To the degree that various individuals (clerks, nurses, physicians) require significant support during prescription generation, a plan should be made continuing the support (e.g., develop or purchase an application with features for "secure prescription-related messages" to initialize and transport prescription-related information to the appropriate chain of individuals in an office). If that is not possible, it is important that the organization recognize that electronic prescription writing will probably require more physician time than the manual process. Otherwise, as described by Ash and colleagues,[10,20,21] a failure to recognize the realities of the manual process could drastically compromise adoption when the system is implemented.

Conclusion

The authors have constructed activity diagrams for outpatient prescribing that have the potential to inform implementations of electronic-prescribing systems. The diagrams can help to catalyze discussions about workflows in sites planning to adopt electronic prescribing systems. These diagrams also provide a template upon which other functional capabilities can be modeled.

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